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Research Summary

Evaluation of Missouri's NBI Data to Predict the Deterioration of Bridges

MoDOT is responsible for the inspection and maintenance of approximately 10,000 bridges and culverts on the state roadway system. The condition of these structures is assessed biannually to monitor deterioration that occurs as a result of environmental exposure and traffic loading. To effectively manage these important assets, MoDOT launched a research effort to develop deterioration models that would allow them to better project future preservation and rehabilitation activities and develop data-driven asset management plans.

The objectives of this research were to develop deterioration curves for different bridge components and culverts, identify trends in deterioration patterns, and develop recommendations for cost-effective bridge types. To conduct this analysis, records from the Federal Highway Administration's (FHWA) National Bridge Inventory (NBI) were obtained for the years of 1983 - 2019. These records document the inspection results from biannual inspection through condition ratings (CR) that describe the condition of bridge components (deck, superstructure, and substructure) and culverts on a 0 - 9 numerical scale

Deterioration curves were developed based on Kaplan-Meir (K-M) method of survival analysis. This methodology calculated the probability or likelihood of a structure to transition to the next lower CR. These data were used to develop median service life estimates for bridge components and culverts formed from different materials.

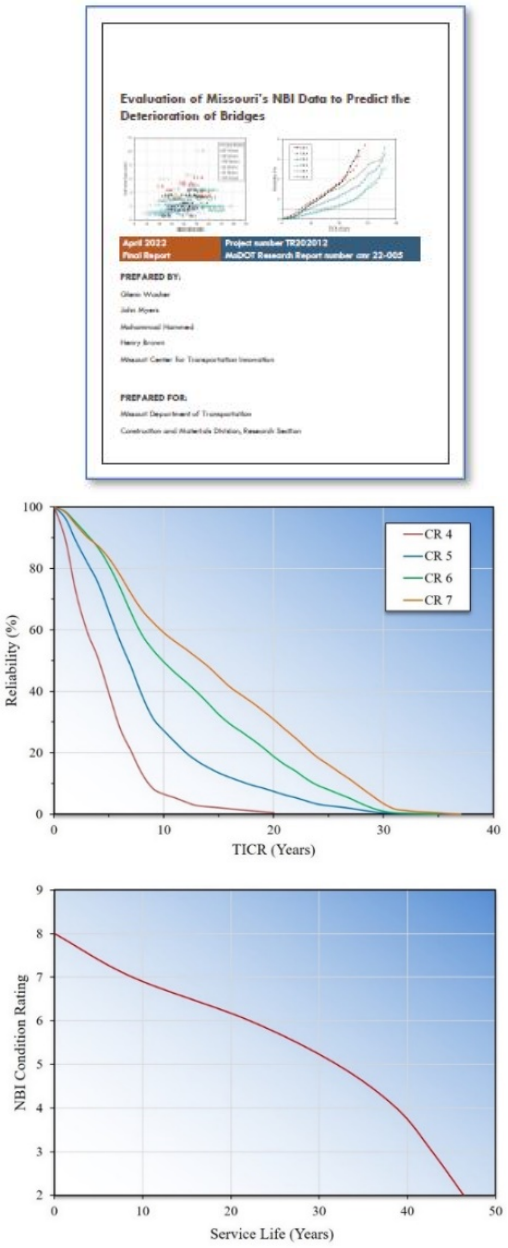

Figure 1: Example research results showing reliability of steel bridges (top) and service life (bottom).

Cox regression analysis was used to identify and quantify trends in the deterioration of different types of bridges MoDOT has built over the years. These data were analyzed to determine the influence of parameters such as the effect of salt application, environment, span length, traffic volume, location, and age.

The research found that the quantity of salt application on the roadway showed a significant influence on the deterioration of both bridge components and culverts.

It was found that bridge decks, critical components for the serviceability of bridges, performed differently depending on the superstructure supporting the deck. For example, concrete bridge decks formed on steel continuous superstructures had longer median service life estimate as compared with prestressed (PSC) bridges. It was also found that bridge decks performed differently in different MoDOT districts across the state.

The primary modern superstructure types, including steel girder and PSC girder bridges, had very similar deterioration patterns between CR 8 (very good condition) and CR 4 (poor condition). PSC box beam bridges had the shortest median service life, while RCC slab bridges had the longest service life. The age of a component or culvert showed a statistically significant effect on its reliability, resulting in increased likelihood of transition to the next lower CR or between 3% and 10% per 10 years of age.

It was also found that in almost all cases, the deterioration rate of structures increased in slope at CR 5 (fair condition), meaning that once a bridge deteriorates to fair condition its rate of deterioration increases as compared to bridges in satisfactory (CR 6) or better condition.

The report also included a section on how to implement the results of the research for asset management such as forecasting future bridge conditions based on the results of the research.

The research resulted in several recommendations regarding implementation of research results. This included implementing preservation strategies to maintain bridge components in good condition where the deterioration rate is lower as compared with components in fair to poor condition. A best-practices review for PSC box beam bridges was also recommended to identify processes that might improve the performance of the bridge type that showed the most rapid deterioration rates. It was also recommended that the trends in the effects of design parameters such as span length or superstructure type be considered in the preliminary design of bridges. Due to the significant influence of salt application on the deterioration of bridges, improved methods of monitoring salt application were recomended to better track and potentially mitigate its detrimental effects.

Project Information

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